THE STATE OF SOFT-SHELL CLAM (*Mya arenaria*) POPULATIONS IN THREE REGIONS OF EASTERN NEW BRUNSWICK

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ABSTRACT

Hicks, C. and Ouellette, M. 2011. The state of soft-shell clam (*Mya arenaria*) populations in three regions of Eastern New Brunswick. Can. Ind. Rep. Fish. Aquat. Sci. 286: viii + 31 p.

Soft-shell clams (*Mya arenaria*) have an important role in our ecosystems and also represent a resource of considerable socio-economic importance to many coastal regions of New Brunswick. The general consensus of fishers, DFO fishery officers, non-governmental organizations (NGO) and the general public is that fishing pressures have increased over the years. Although we do not possess the data proving that overfishing is occurring, we are observing declines in the landings. Various socio-economic factors could explain some of the observed trends and declines in the statistical data, but ecological factors, such as reductions in the productivity of soft-shell clam populations and the degradation of habitats, may be significant. In 2006, the state of the soft-shell clam populations was investigated in three regions of New Brunswick: the Richibucto estuary, the Tabusintac estuary and Heron Island. Information was gathered concerning the whereabouts of soft-shell clam beds in these regions by interviewing local fishermen, fishery officers and NGOs. Three maps (one for each region) were produced to reflect this local knowledge. The productivity and stock status of clam beds in the Aldouane River (Richibucto region) was evaluated in more details, as a case study. This was done by mapping the location and size of clam beds using a GPS and taking samples from chosen clam beds. Some background information concerning the management of the soft-shell clam fishery, history of zone classifications, licenses issued and landing values over the years are also discussed in this report.

RÉSUMÉ

Les myes (*Mya arenaria*) occupent un rôle important dans nos écosystèmes et représentent aussi une ressource d'importance considérable sur le plan socio-économique de plusieurs régions côtières du Nouveau-Brunswick Le consensus général des pêcheurs, officiers de pêches, organismes non-gouvernementaux (ONG) et du publique en général est que l'effort de pêche a augmenté au cours des dernières années. Malgré que nous n'ayons pas accès à des données pour supporter l'existence d'une surpêche, un décline des débarquements est évident. Plusieurs facteurs socio-économiques pourraient expliquer certaines tendances observées ainsi que les données statistiques en baisse. Cependant autres facteurs écologiques, tel qu'une réduction de productivité biologique des myes ou la dégradation de l'habitat pourraient jouer un rôle significatif. En 2006, l'état de la population de myes a été étudié dans trois régions du Nouveau-Brunswick: l'Île aux Hérons et les estuaires de Richibucto et Tabusintac. L'information concernant la position géographique des gisements de myes dans chacune des régions a été recueillie à partir d'entrevues avec les pêcheurs, officiers de pêche et les ONG de ces régions respectives. Trois plans (un par région) ont été produits pour représenter les connaissances traditionnelles. La productivité et l'état du stock de myes de la rivière Aldouane (région de Richibucto) ont été évalués de façon plus détaillé, dans le cadre

d'une étude de cas. Les positions géographiques (GPS) ainsi que la densité des gisements étudiés ont été déterminés à partir d'échantillonnage sur terrain. Une discussion sur l'information de base de la gestion de la pêche, les zones de classification, l'émission de permis et les données de débarquements au cours des années suit dans ce rapport.

1.0. INTRODUCTION

Soft-shell clams (*Mya arenaria*) are bivalve molluscs found in the intertidal to subtidal zones of coastal embayments from Labrador to South Carolina (Hidu and Newell, 1989; and Newell, 1991). This species plays an intricate role in our ecosystems and also represents a resource of considerable socio-economic importance to many coastal regions of New Brunswick. Among the various commercially exploited clam species, including the bar clams (*Spisula solidissima*) and quahaugs (*Mercenaria mercenaria*), the soft-shell clam is the most important for Eastern New Brunswick. From 2000 to 2003, the soft-shell clams accounted for 67% of all landings, among clam species in Eastern New Brunswick, which translates into a mean annual value close to $830,000 with landings of 465 metric tons (Fisheries and Oceans Canada, 2006). From 2004 to 2007, soft-shell clams accounted for 60% of all landings. However, the mean annual value for that period decreased to approximately $680,000 with landings of 340 metric tons.

Although one can look at reported landings for an indication of the state of our soft-shell clam resources, it does not give a clear picture of what is happening. Landings fluctuate yearly depending on the number of active fishing licenses, individual fishing efforts and length of fishing season. Furthermore, landing values are underrepresented due to unreported landings, lack of documentation on the commercial fishery in earlier years, and the non existing data concerning the recreational fishery. The best evidence or indication of the state of our soft-shell clam populations comes from individuals who are in the field. Many individuals have made their livelihood on the shores of New Brunswick and have seen first hand the changes over the years. The general consensus of fishers, DFO fishery officers, NGOs and the general public is that fishing pressures have increased over the years (Fisheries and Oceans Canada, 2001). Although we do not possess the data proving that overfishing is occurring, we are observing declines in the landings.

Overfishing is likely to have serious consequences on our soft-shell clam stocks and for this reason there has been increasing concern over the state of our soft-shell clam fishery. Successful management of the fishery is a key issue in protecting our soft-shell clam stocks. In order to be successful, past management procedures need to be evaluated and new insights are needed to improve current and future management practices. Ultimately it will be the individuals in the field who will safeguard this resource. The knowledge and concerns of these individuals are a valuable resource. Also important to the management of the fishery is the gathering of baseline information concerning the productivity and stock status of soft-shell clam populations. Without knowing what was there to begin with, it is difficult to evaluate the success of a management plan.

In efforts to look at the state of the soft-shell clam populations in New Brunswick focus was placed on three regions; the Richibucto estuary, the Tabusintac estuary and Heron Island (Figure 1). Information was gathered concerning the whereabouts of soft-shell clam beds in these regions by interviewing local fishermen, fishery officers and

NGOs. The productivity and stock status of clam beds in the Aldouane River (Richibucto region) was evaluated in more details, as a case study. This was done by mapping the location and size of clam beds using a GPS and later taking samples from chosen clam beds. This gathering of baseline information is of great importance and can be used in evaluating management or conservation efforts and in describing future productivity of the areas. Some background information concerning the management of the soft-shell clam fishery, history of zone classifications, licenses issued and landing values over the years are also discussed in this report.

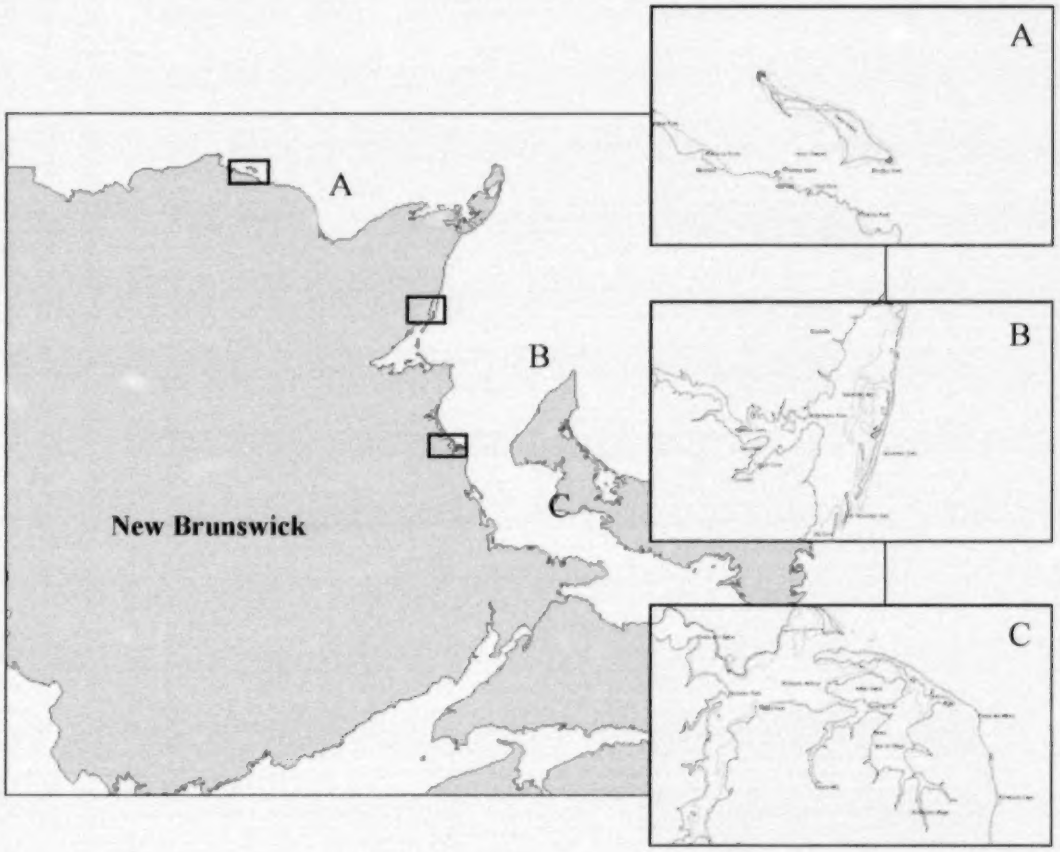

Figure 1. Map of New Brunswick showing the three study regions; (A) Heron Island region, (B) Tabusintac region and (C) Richibucto region.

2.0. METHODOLOGY

2.1. INFORMATION RESEARCH

Literature concerning the soft-shell clam fishery in New Brunswick was gathered using the Aquatic Science and Fisheries Abstracts (ASFA) and WAVES (DFO's library catalogues) search engines. The internet was also used as a research tool to access non-government databases and on-line publications. Web page references in this document were active at the time the document was written. A valuable resource was personal communications with fishers, fishery officers and NGOs. This gave us knowledge of and access to not as readily available literature and undocumented information. During interviews in the three study regions, individuals were shown a map of the region where they fish and asked to indicate the location of soft-shell clam beds. Individuals were very generous with their knowledge and were willing to offer future assistance.

2.2. FIELD WORK

Sampling surveys were only conducted for the Richibucto region and was conducted during the months of September and October of 2006. Clam beds on the southern shore of the Aldouane River were mapped with a hand-held GPS (Garmin Map76) by walking around the perimeter of the clam beds. Generally, the clam beds were mapped up to the beginning edge of the eel grass patches. Following the mapping, seven sample stations (on clam beds number 1, 5, 9, 13, 23, 27 & one unmapped clam bed on the northern shore (Station 7)) were chosen by focusing on the larger clam beds along the shore of the Aldouane River (see Figure 8, p. 12). Approximately 3 to 5 sites were randomly chosen and sampled (in triplicate) from each sample station. A total of 93 samples were collected to determine conditions of clam populations. Also, a total of 30 sediment samples were collected from the 7 sample stations for organic matter and granulometry analysis (see Appendix 1). Furthermore, sediment samples for sulfide analysis (see Appendix 2) were collected from sample stations 1, 4 & 6. It took several hours over several days to map the clam beds on the southern shore of the Aldouane River, while sampling of the selected clam beds took place over a period of two days.

Samples of soft-shell clams were collected using a 0.25 m^2 ring and a suction pump using the Venturi principle. A small boat was required to run the Venturi pump in knee deep to hip deep water. The Venturi pump had a mesh bag (mesh size ~ 4 to 5 mm) that was used to collect the samples while still allowing for the removal of sediment and other small debris. The samples were then transferred to a labeled ziplock bag. Sediment samples for granulometry and organic matter analysis were collected using a suction corer and placed in a labeled ziplock bag. A suction corer was also used to collect sediment samples (~ 5ml) for sulfide analysis, which were collected in triplicates from the sediment-water interface and from a deeper layer (~ 5-10cm). These samples were placed in amber vials and brought back to the lab on the same day for sulfide analysis (refer to Wildish *et al.*, 1999 for sulfide analysis procedure). Samples collected with the Venturi pump and sediment samples collected for granulometry and organic matter analysis were frozen until they could be processed at a later date.

Soft-shell clams were counted, weighed, measured (length) and an estimate age was noted. Organic matter content was analyzed by placing a measured amount of wet sediment (~5 to 15g) into a pre-weighed aluminum tray. The sample was then re-weighed after drying for 20 hours at 70 °C and again after burning for 8 hours at 500 °C. A larger sediment sample (~80-100g) was measured out for granulometry. Granulometry samples were dried and burned following the same procedure as for the organic matter analysis. Samples were then sieved through a set of 8 sieves (> 4mm, 2-4 mm, 1-2 mm, 0.5-1 mm, 0.25-0.5 mm, 0.125-0.25 mm, 0.063-0.125 mm, <0.063 mm) for 15 minutes using a mechanical shaker (Fritsch, analysette 3 Spartan, pulverisette 0).

2.3. MAPPING

Maps of the clam beds were constructed using MapInfo Professional v7.0.

3.0. EASTERN NEW BRUNSWICK

3.1. MANAGEMENT OF THE SOFT-SHELL CLAM FISHERY

The soft-shell clam fishery in New Brunswick is characterized by three components, which include i) Open water commercial, ii) Contaminated (and Conditionally approved) Commercial and iii) Recreational. Soft-shell clams are harvested by hand or with the use of hand held tools such as picks, clam hoes and shovels. Both the recreational & commercial fisheries are subject to open and closed fishing seasons. Currently the recreational fishery has a catch limit of 100 soft-shell clams per day and both recreational & commercial must adhere to the 50 mm legal size limit. There is no daily catch limit for the commercial fishery, however, commercial fishing licenses are mandatory and have been since 1994 (Fisheries and Oceans Canada, 1996). Prior to 1994, harvesting was barely monitored and clams under the recommended size limit (38 mm at the time) were still lawfully being harvested (Fisheries and Oceans Canada, 2001). Furthermore, at that time there were no catch limits on the recreational fishery. Further information concerning management of the soft-shell clam fishery can be found in the Fisheries and Oceans Report on "The *Integrated Management Plan of the Clam Fishery - Eastern New Brunswick Area 2001-2006*".

3.2. LANDING VALUES & LICENSES

Soft-shell clam landings and values for Eastern New Brunswick (between statistical districts 63 and 80) from 1984 to 2007 are shown in Figure 2. These values include the reported landings of soft-shell clams from both contaminated and non contaminated areas. It is important to keep in mind that these values are under represented due to unreported landings, lack of documentation on the commercial fishery

in earlier years, and the non existing data in relation to the recreational fishery. Soft-shell clam fishing licenses issued for Eastern New Brunswick (between statistical districts 63 and 80) from 1994 to 2006 are presented in Table 1.

Among soft-shell clams, bar clams and quahogs, the soft-shell clam is the most important commercially exploited clam species in Eastern New Brunswick. From 1999 to 2007, the soft-shell clam accounted for 76% of all landings while bar clams and quahogs accounted for 16% and 8% respectively (Figure 3) (Fisheries and Oceans Canada, 2006). The landed value percentage of these species from 1999 to 2007 is as follows; 75% for soft-shell clams, 15% for bar clams and 10% for quahogs (Figure 4).

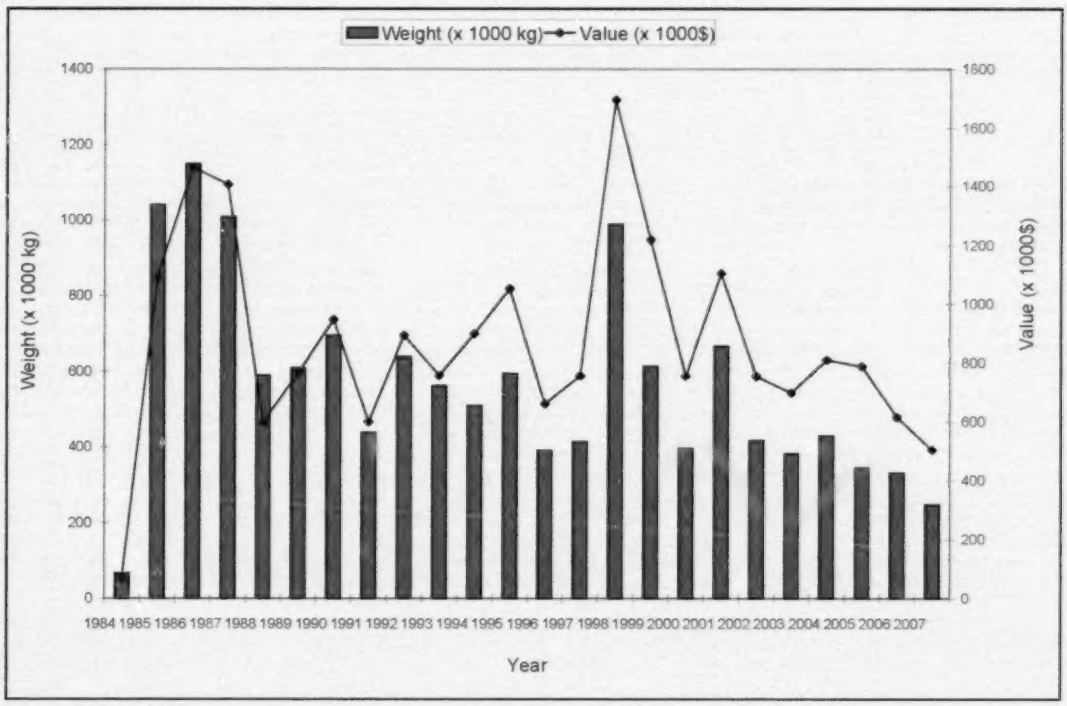

Figure 2. Soft-shell clam landings & value for New Brunswick from 1984 to 2007. *(Modified from Fisheries and Oceans Canada, 2006)*

Table 1. Soft-shell clam fishing licenses issued for New Brunswick from 1994 to 2006.

Fishers													
Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
New Brunswick	868	1063	810	701	683	680	682	675	660	652	642	623	583
First Nations													
New Brunswick	0	0	0	0	0	1	1	1	10	15	18	22	22
Total	868	1063	810	701	683	681	683	676	670	667	660	645	605

(Source: Pers. Com. Michel Bourque – DFO)

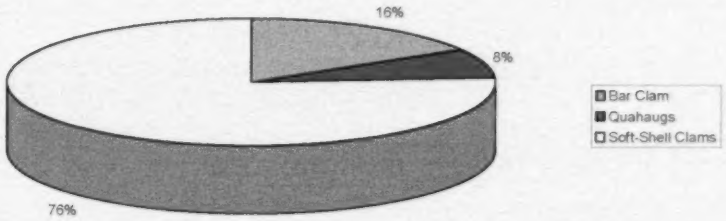

Figure 3. Landing percentage of soft-shell clams, bar clams and quahaugs from 1999 to 2007.

(Modified from Fisheries and Oceans Canada, 2006)

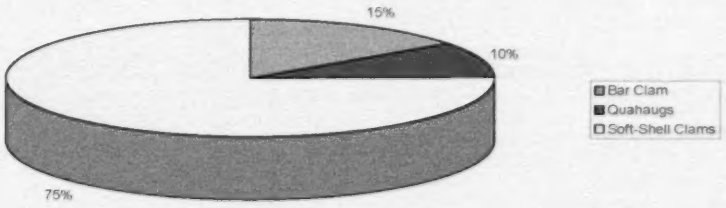

Figure 4. Landed value percentage of soft-shell clams, bar clams and quahaugs from 1999 to 2007.

(Modified from Fisheries and Oceans Canada, 2006)

4.0. RICHIBUCTO

4.1. DESCRIPTION OF AREA & HISTORY

The Richibucto watershed is composed of the Richibucto Bay, Baie du Village, the Aldouane River, Richibucto River, St. Nicolas River and all associated waterways. The entire watershed has an area greater than 1400km^2 (Richibucto River Association). Together the Richibucto River and Bay is approximately 32 km long and up to 4 km wide, while the Aldouane River is approximately 7 km long and up to 2 km wide (Richard and Godin, 2004). Depths are quite shallow in all regions except in the channel. Eel grass (*Zostera marina*) is abundant and it is estimated to cover 76.7% of the total surface area of the Richibucto watershed (SenPaq Consultants, 1990). The sediment type in the area is mostly mud (33.8% soft mud and 21.2% compact mud) and sand (23.3%) or mud-sand (17.4%) (SenPaq Consultants, 1990).

The Richibucto watershed is used by fishers, clam diggers, aquaculturists, recreational boaters, bird hunters and picnickers. Some of the land uses in the area include agriculture and peat moss harvesting. As well, there are many cottages and houses found along the banks of the Richibucto watershed. The Richibucto watershed encompasses the towns of Richibucto (pop:1469), Rexton (pop: 940), and Elsipogtog First Nations community (pop:1800) (Richard and Godin, 2004).

The northern shore of the Aldouane River is part of the Kouchibouguac National Park. In 2001, The Kouchibouguac Commercial Clam Fishermen Association (KCCFA) was established. The KCCFA is involved with aspects of clam management and are actively involved with restoration techniques and population inventories (Parks Canada, 2009). The Kouchibouguac Park Conservation staff is also involved in soft-shell clam management related issues within the park. There have been two soft-shell clam fishery closures in the park. The first closure was from April 1, 1997 to March 31, 1999 and the second closure was from April 1, 2002 to May 30, 2007. Both closures occured after clam inventories did not meet the following conservation criteria: the commercial-sized clams (> or = 50mm) represent densities above 12 clams/m^2 and total population represent densities above 100 clams/m^2. The closures were implemented to allow spawner's stock recovery and to ensure the long-term protection of the resource.

Also involved in the soft-shell clam community are non-profit organizations such as the Richibucto River Clam Fishers Association (RRCFA) and the Richibucto River Association (RRA). The RRCFA formed in the early 2000's and their main objective is to restore the soft-shell clam populations in the Richibucto watershed. The RRA is a volunteer-based group formed in March of 1994. Their goals are to preserve and improve the environmental quality of the Richibucto River and its tributaries (Richibucto River Association).

4.2. LANDING VALUES & LICENSES

Soft-shell clam landings and values for the Richibucto region from 1985 to 2007 are shown in Figure 5. These values include the reported landings from both contaminated and non-contaminated areas. Note that the landings do not represent a statistical district but rather ports of the Richibucto watershed. It is difficult to identify the precise region that soft-shell clams were harvested from since they can be transported and reported at various ports. Figure 6 shows where the landings were reported. Soft-shell clam fishing licenses issued in the Richibucto region from 1994 to 2006 are presented in Table 2.

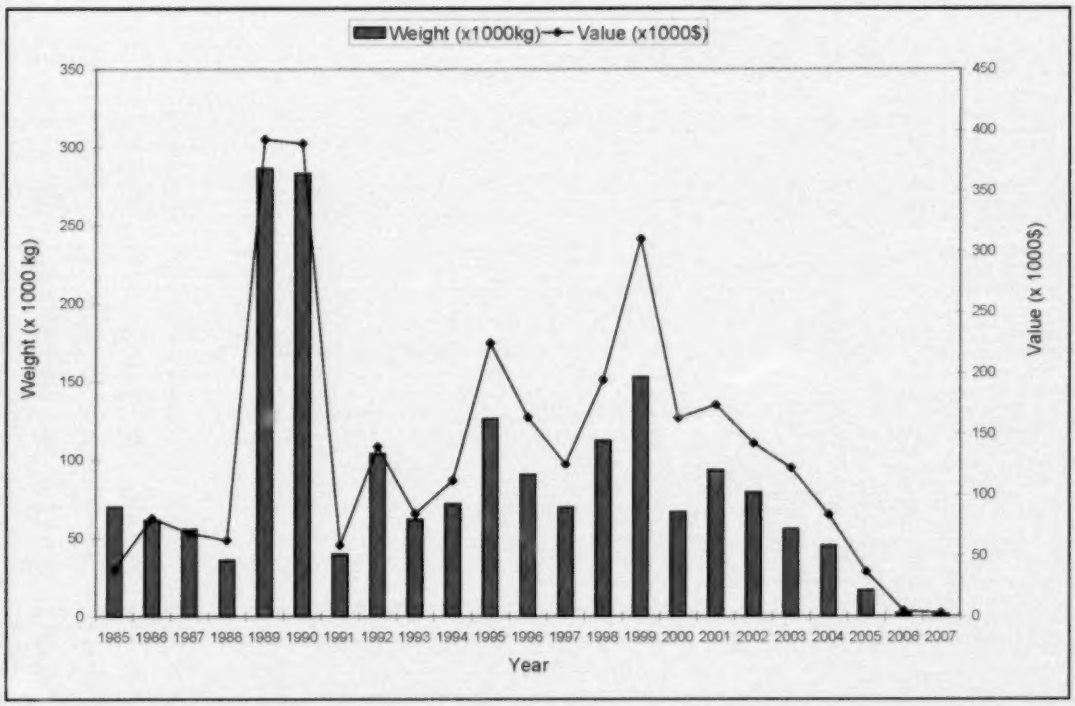

Figure 5. Soft-shell clam landings & value for Richibucto, NB from 1985 to 2007. *(Modified from Fisheries and Oceans Canada, 2006)*

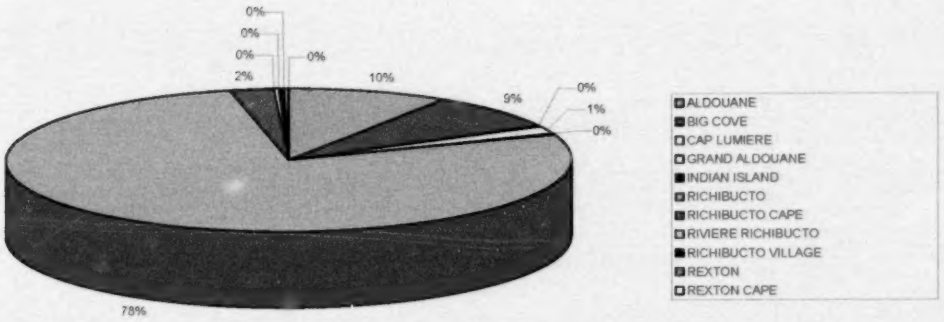

Figure 6. Soft-shell clam percent landings contribution by port for the Richibucto region. *(Modified from Fisheries and Oceans Canada, 2006)*

Table 2. Soft-shell clam licenses issued in the Richibucto region by port from 1994 to 2006.

Fishers													
Port	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Aldouane	0	1	1	1	1	2	3	3	2	2	2	2	1
Cap Lumiere	7	10	8	8	7	7	11	8	18	19	17	17	16
Rexton	2	5	3	1	1	1	1	1	1	1	1	0	0
Richibucto	91	94	69	67	63	67	63	67	69	69	68	62	50
Richibucto Cape	21	31	26	25	25	25	20	15	6	6	6	4	4
Elsipogtog	1	1	0	0	0	0	0	0	0	0	0	0	0
Richibucto Village	7	7	5	3	3	3	4	3	2	2	2	2	2
St. Charles	1	1	1	1	1	1	1	1	1	1	1	1	1
First Nations													
Richibucto	0	0	0	0	0	0	0	0	0	0	2	2	2
Elsipogtog	0	0	0	0	0	0	0	0	9	11	11	15	15
Total	130	150	113	106	101	106	103	98	108	111	110	105	91

(Source: Pers. Com. Michel Bourque – DFO)

4.3. LOCAL KNOWLEDGE

Fishers from the Richibucto region were interviewed in the fall of 2006. Fishers interviewed from the Richibucto region all had ~ 30 years experience harvesting soft-shell clams. Their fishing season extends anywhere from April to December. The number of hours they spend digging clams per day varies between 2 to 15 hours and dig on average 15-20 pecks per day. About half and sometimes more than half of the soft-shell clams are rejected due to small size and are left on the banks uncovered. Boats are used to reach harvesting areas and clams are dug by hand or with the use of hand held tools.

The general consensus concerning the Richibucto region is that soft-shell clam stocks are decreasing to dangerous levels. In particular, many individuals described the changes seen in the Aldouane River over the years. Emphasis was placed on how rich with clams the Aldouane River used to be and how little there is left today. At one time, the Aldouane River alone was thought to be richer in clams than the entire rest of the Richibucto river system. A similar story is told about the decline of soft-shell clams in many regions of the Richibucto watershed. Nicolas River and Dead man's island are a couple regions where there are thought to be good populations of clams remaining.

Stocks that were once protected in contaminated areas are now being fished with no limits for the depuration fishery. Comments were made concerning the management of the depuration fishery. Prices set by the depuration fishery influences the effort fishers put into their catch. For example, if prices are low, individuals will need to compensate by collecting more clams. Furthermore, this may translate into the collection of clams under the legal size limit in order to reach their targeted amount. Problems can also arise if prices are set too high.

The Richibucto River has numerous access roads and is therefore a generally very accessible region. The shoreline and sand bars of the Richibucto River are being impacted from the activities and large numbers of individuals that are able to access the region. Figure 7 displays the location of soft-shell clam beds according to the knowledge of fishers, DFO officers and NGOs.

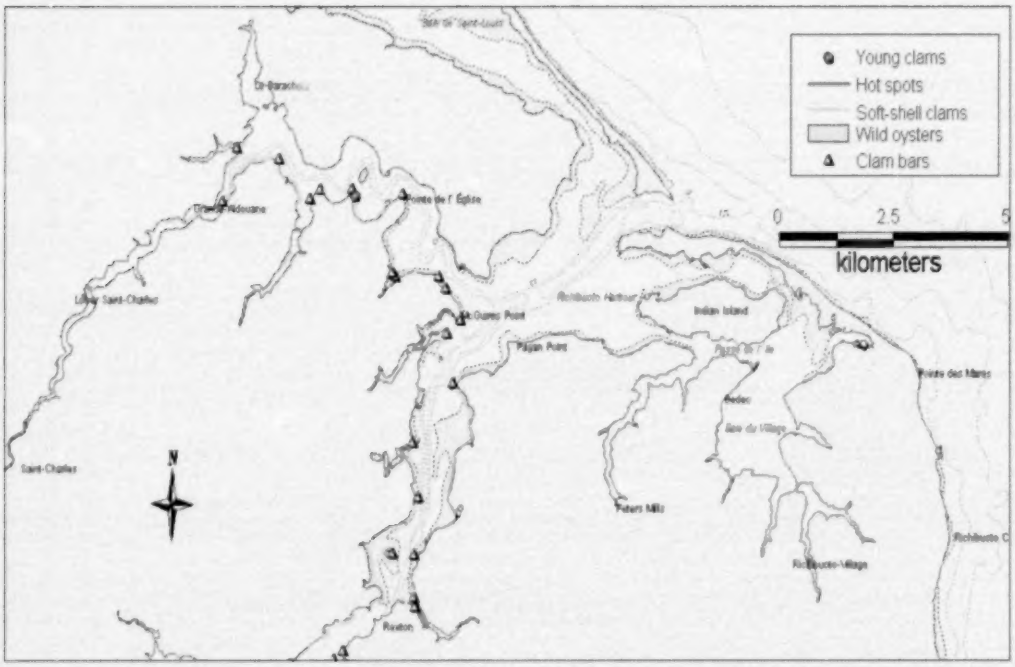

Figure 7. Map of the Richibucto watershed showing location of soft-shell clams according to the local knowledge of fishers, fishery officers and NGOs

4.4. CASE STUDY: ALDOUANE RIVER

A total of 27 clam beds were mapped on the southern shore of the Aldouane River (Figure 8). A division was made between clam bars and shore clams. This is an arbitrary division based on the area that the clams are found *ie*. sand bar or shoreline. Other clam bed divisions were either a result of a natural division or an obstacle such as a wharf. Area (m^2) of the mapped clam beds are presented in Table 3 (Refer to Figure 8 for location of clam beds).

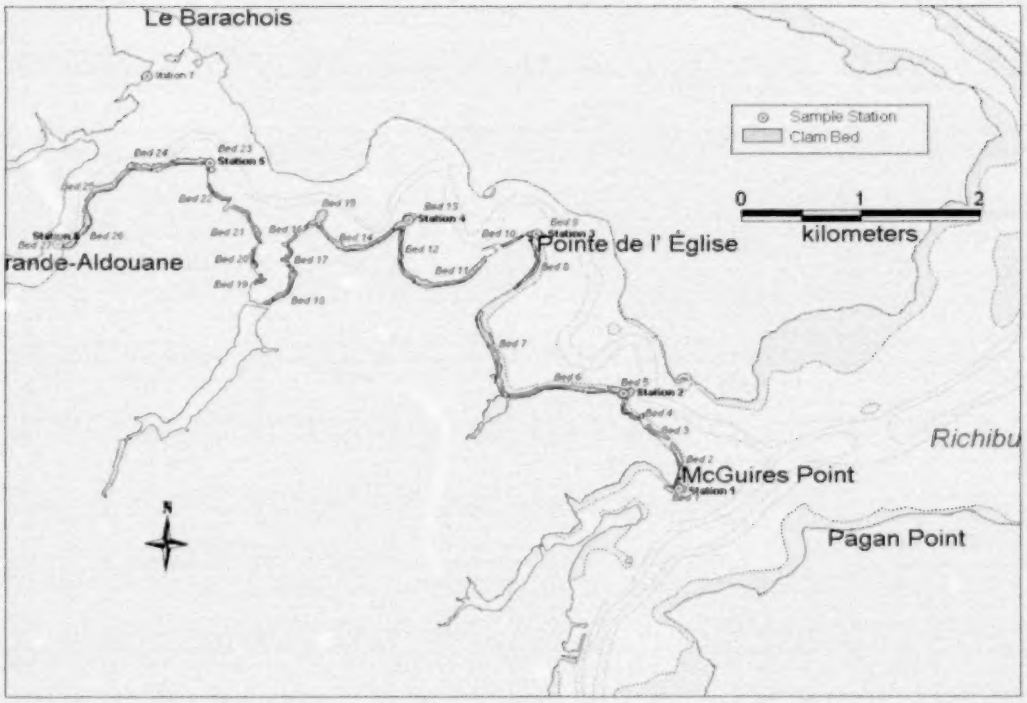

Figure 8. Map showing mapped clam beds along the southern shore of the Aldouane River.

At low tide, clam bars present large areas ideal for clam digging and therefore fishers tend to focus their efforts in these areas. For this reason, the seven sampling stations were chosen with a focus on clam bars. The average number of legal size clams/m^2 ranges from 0 to 12.33 and the percentage of legal size clams per station ranges from 0 to 13.16% (Table 4).

Greater numbers of clams are seen as you move further upstream of the Aldouane River (from Station 1 to Station 6). Station 7, which is found on the opposite side of the channel, is the only station that does not follow this trend. Clam distribution is likely influenced by gregarious settlement, predation effects and hydrodynamic factors (Newell, 1991). Haemic neoplasia was confirmed present in Mooney's creek (in the vicinity of sample Station 1) in the late 1990's to early 2000's (Pers. Com. DFO Shellfish Health Section). Haemic neoplasia is a shellfish disease that can cause mass mortalities in soft-shell clams by interfering with normal cell development. Large numbers of broken and empty soft-shell clam shells were observed while conducting field work for this project along the southern shore of the Aldouane River.

Size distributions of soft-shell clams for each station are shown in Figures 9 to 15. Class size 0-5 mm may be underrepresented due to the size of sampling mesh used (4-5mm). The general trend is a greater average size as you move from station 1 to station

7. At Station 1 the average size is 5-10 mm and at station 7 the average size is 25-30 mm. At Station 1 there are a few legal sized clams, however, there is an absence of clams between 15-55 mm. Similarly at Station 2 there is an absence of clams over 20 mm. Stations 3 to 6 show a skewed distribution with smaller frequencies at the larger class sizes, while Station 7 shows a relatively normal distribution.

Length vs. weight was plotted for 139 soft-shell clams (Figure 16). These random 139 soft-shell clams do not come from one clam bed but rather from a collection of the seven sample stations. The resulting equation is $y = 0.0002X^{2.7541}$ and $R^2 = 0.988$. As a general estimate the majority of soft-shell clams found at station 1 were 0-2 years of age, at stations 2 & 3 they were 0-3 years of age, at station 4 they were 0-4 years of age and at stations 5, 6 & 7 they were 2-4 years of age.

Percent organic matter among the seven clam beds showed little variation with a range of 1.14 to 2.14% (Figure 17). Sulfide analysis was done on sediment collected from sample stations 1, 4 & 6 only. The sulfide levels found at the sediment-water interface compared to ~5 - 10 cm sediment layer were significantly different at stations 4 & 6 (Figure 18). Comparison between sample stations showed that sulfide levels at the sediment-water interface were similar, while sulfide levels at the ~5 to10 cm sediment layer were significantly different. Sulfide values averaged between 22.98 ± 5.04 µM and 139.21 ± 34.66 µM. Overall, these levels are all under 300 µM and therefore represent normal organic enrichment condition (refer to Appendix 2 for table on organic enrichment stages in correspondence with Eh_{NHE} and total sulfide values).

D50 values for the seven sample stations ranged from 0.239mm and 0.424mm (Table 5). These values all represent the same grain size ($\geq$ 0.0625mm and $<$ 2.0mm) and are classified as sand (refer to Appendix 1 for sediment classification according to grain size).

Table 3. Area (m^2) of clam beds with closure status and clam bed type.

Clam Bed	Area (m^2)	Type	Status
*1	11140	Clam Bar	Closed
2	10920	Shore Clams	Closed
3	6321	Shore Clams	Closed
4	5396	Shore Clams	Closed
*5	13360	Clam Bar	Closed
6	20390	Shore Clams	Closed
7	31000	Shore Clams	Closed
8	10570	Shore Clams	Closed
*9	7785	Clam Bar	Closed
10	3201	Shore Clams	Open
11	24710	Shore Clams	Open
12	4701	Shore Clams	Open
*13	13100	Clam Bar	Open

14	20570	Shore Clams	Open
15	11370	Clam Bar	Open
16	5537	Shore Clams	Open
17	4268	Shore Clams	Closed
18	12190	Shore Clams	Closed
19	3127	Shore Clams	Closed
20	2713	Shore Clams	Closed
21	8785	Shore Clams	Open
22	4308	Shore Clams	Open
*23	14030	Shore Clams	Open
24	13720	Shore Clams	Open
25	17240	Shore Clams	Closed
26	18160	Shore Clams	Closed
*27	1955	Clam Bar	Closed

* *Represents sample stations*

Table 4. Stations with corresponding clam bed number, area (m^2), average # of clams/m^2, average # legal/m^2, % legal and sample size (n).

Station	Corresponding clam bed	Area (m^2)	Average # clams/m^2 ± SE	Average # legal/m^2 ± SE	% legal	n
1	1	11140.00	12.67 ± 4.17	1.67 ± 1.04	13.16%	12
2	5	13360.00	225.33 ± 46.22	0.00 ± 0.00	0%	15
3	9	7785.00	246.13 ± 42.08	10.40 ± 1.86	4.22%	15
4	13	13100.00	487.20 ± 81.25	7.20 ± 1.71	1.48%	15
5	23	14030.00	542.93 ± 93.72	5.07 ± 1.38	0.93%	15
6	27	1955.00	1009.33 ± 114.96	12.33 ± 2.38	1.22%	12
7	n/a	unknown	58.22 ± 20.81	1.79 ± 0.97	3.05%	9

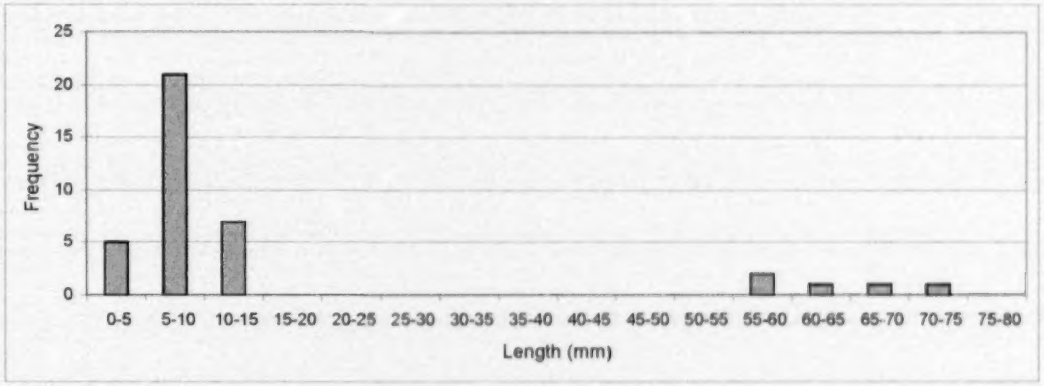

Figure 9. Size distribution of soft-shell clams from Station 1 (n = 38).

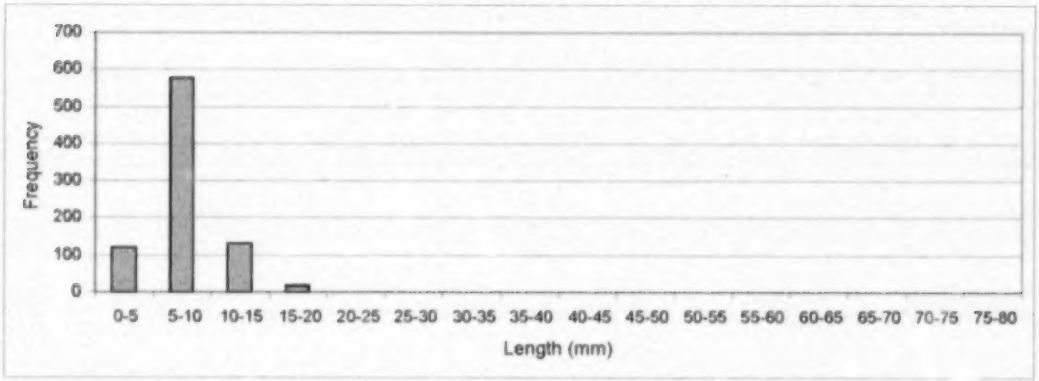

Figure 10. Size distribution of soft-shell clams from Station 2 (n = 845).

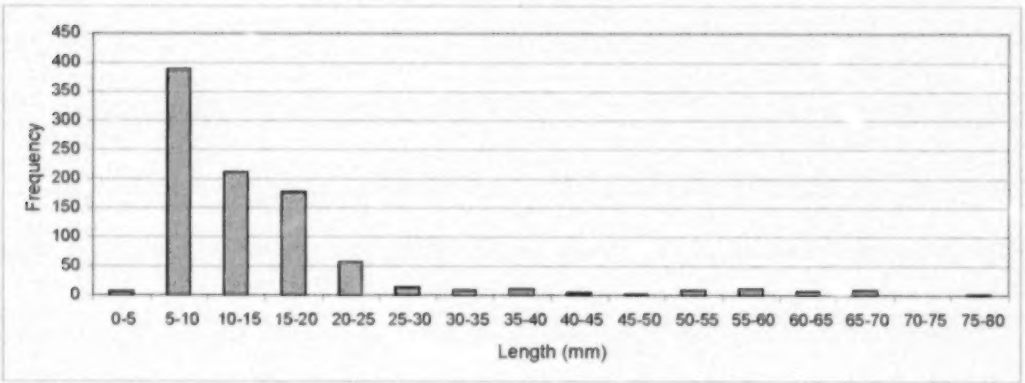

Figure 11. Size distribution of soft-shell clams from Station 3 (n = 923).

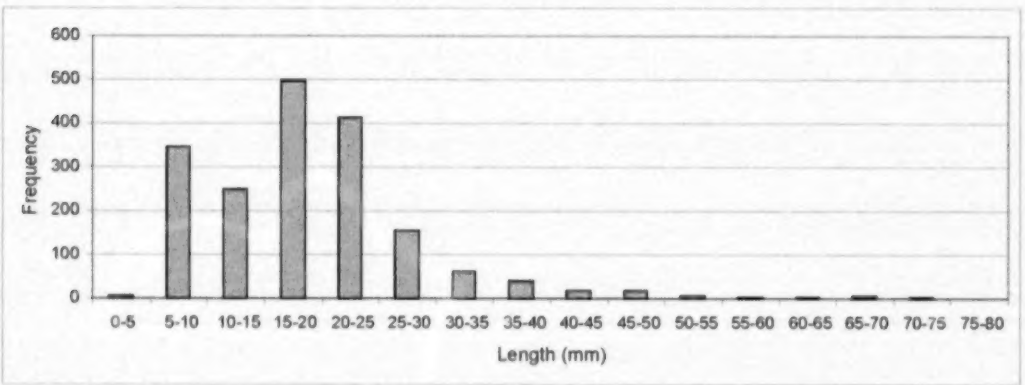

Figure 12. Size distribution of soft-shell clams from Station 4 (n = 1827).

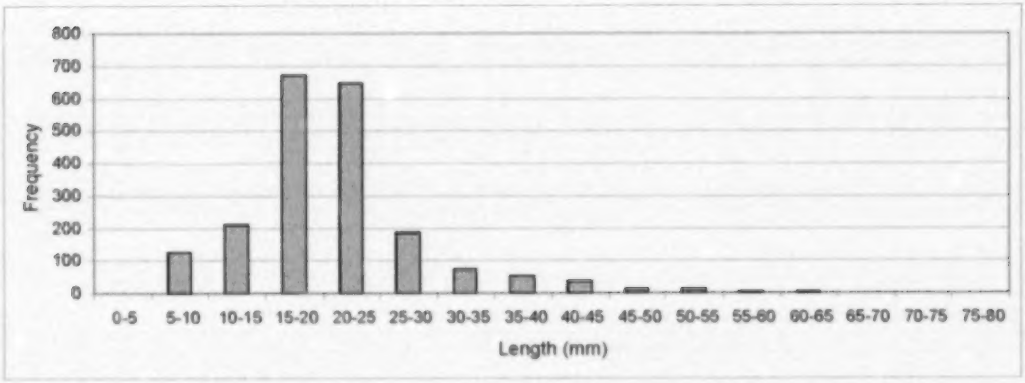

Figure 13. Size distribution of soft-shell clams from Station 5 (n = 2036).

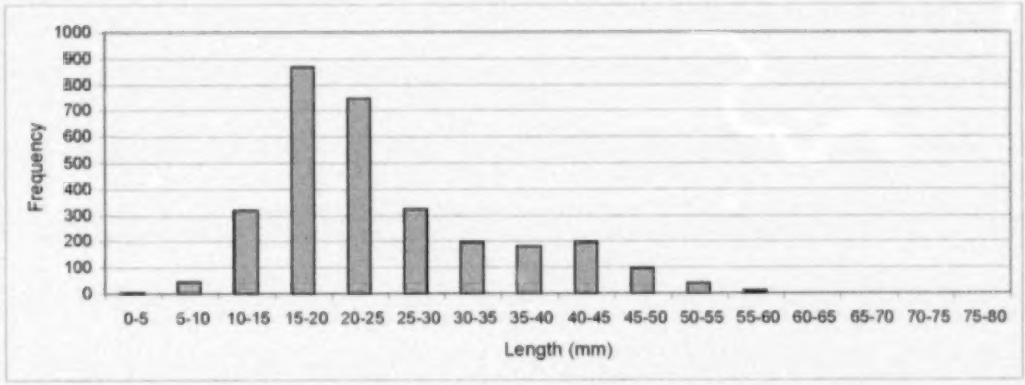

Figure 14. Size distribution of soft-shell clams from Station 6 (n = 3028).

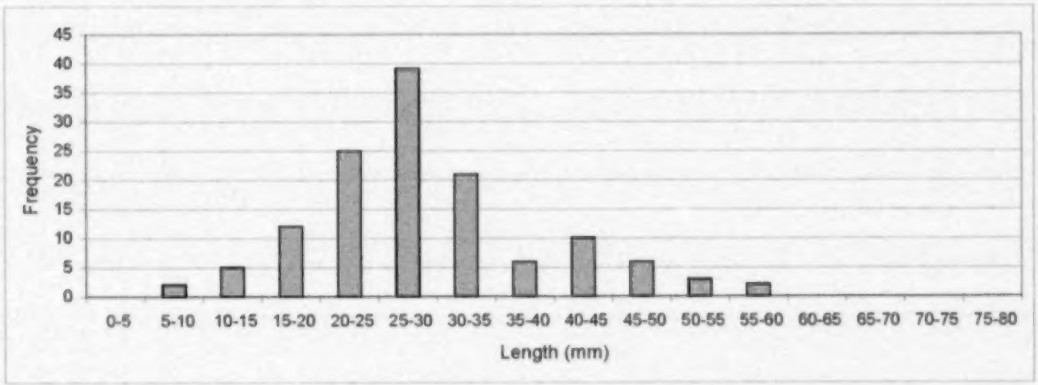

Figure 15. Size distribution of soft-shell clams from Station 7 (n = 131).

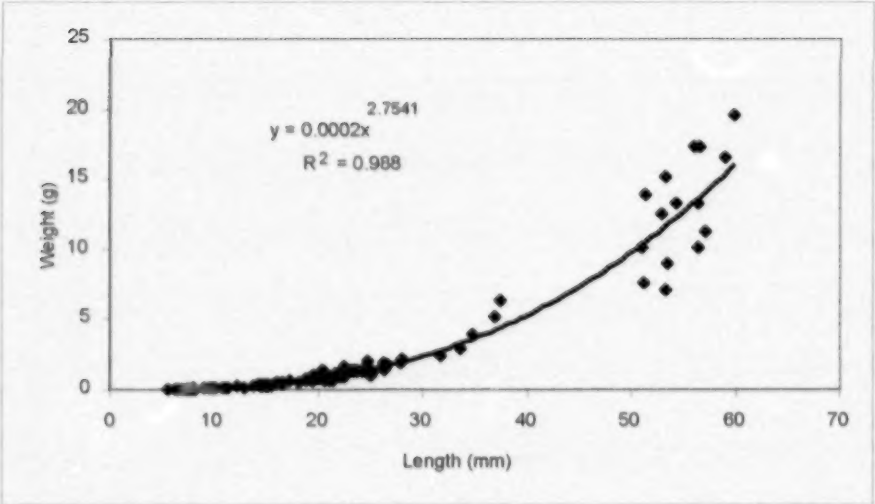

Figure 16. Length (mm) vs. weight (g) plot of soft-shell clams (n = 139) from seven clam beds of the Aldouane River.

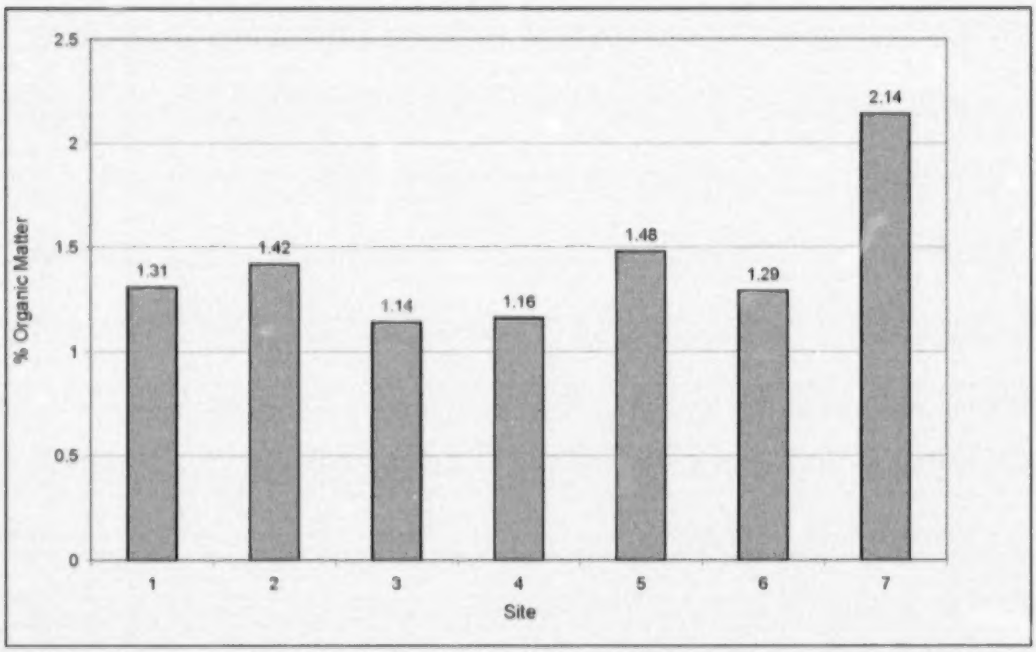

Figure 17. Organic matter percentage (average) per sample station.

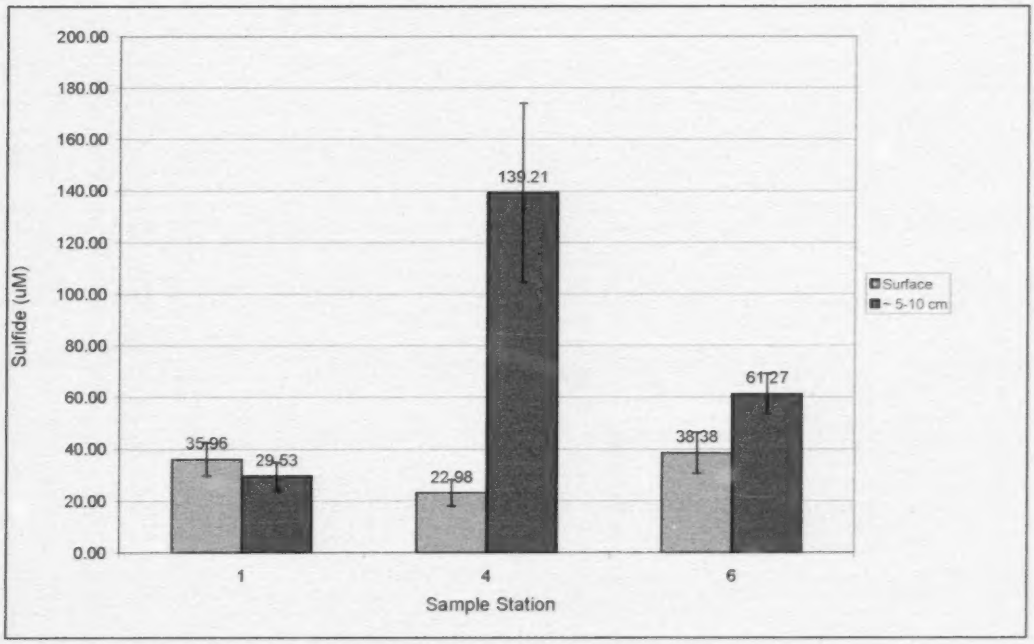

Figure 18. Sulfide values and standard error (SE) bars from the sediment-water interface (surface) and at a depth of ~5-10 cm for sample stations 1, 4 & 6 (n=3).

Table 5. D50 values for seven sample stations.

Station	D50 Value
1	0.297
2	0.289
3	0.312
4	0.348
5	0.270
6	0.424
7	0.239

4.5. DISCUSSION

The number of legal size clams found at the seven sample stations on the southern shore of the Aldouane River are quite low (range from 0 to 12.33 ± 2.38/m^2). Sample stations were very similar in percentage of organic matter, sulfide levels and grain size. These results also indicate that some of the basic requirements for a suitable habitat for soft-shell clams are present. In general there are greater abundances and larger average sizes of soft-shell clams as you move upstream of the Aldouane River (from station 1 to station 7).

Lamoureux (1977) describes a soft-shell clam population as being overexploited when commercial sized clams (≥ 50 mm) represent less than 15% of the total population and the commercial density is below 12 clams/m^2. According to these standards, all clam beds sampled in the Aldouane River would be considered over-harvested (Table 4). However, sampling for this project represents a snapshot of what is out there. A population survey requires more intense sampling both in method and number of samples collected.

5.0. TABUSINTAC

5.1. DESCRIPTION OF AREA & HISTORY

The Tabusintac watershed "comprises 200 ha of salt marsh, 3,400 ha of subtidal estuarine water and flats, 400 ha of intertidal estuarine flats, 10 ha of saline ponds, 30 ha of sand dunes, 60 ha of sand beach, 2 ha of islands, and 295 ha of black spruce – jack pine forest" (Tabusintac Watershed Association). Eelgrass (*Zostera marina*) is abundant in the area and is estimated to cover over 80% of the total surface area. Water depth in the area averages 1-2 meters with a maximum of 3 meters.

The Tabusintac watershed is used by clam diggers, picnickers, fishers, aquaculturists, bird hunters and users of all-terrain vehicles. Land use in the area includes agriculture and peat moss harvesting. The Tabusintac watershed encompasses the remote communities of Tabusintac (Pop: 893), Burnt Church First Nation Eskinuopitijk (Pop: 1,562), and Brantville (Pop: 1,153) (populations as of 2006).

Of interest to the soft-shell clam community is the Tabusintac Watershed Association, which was established in 1998. Their mission is to "achieve and maintain a healthy ecosystem for the Tabusintac Watershed; where a healthy ecosystem includes all environmental, economic and social components related to the watershed" (Tabusintac Watershed Association).

5.2. LANDING VALUES & LICENSES

Soft-shell clam landings and values for the Tabusintac region from 1985 to 2007 are shown in Figure 19. These values include the reported landings from both contaminated and non-contaminated areas. Note that these landings do not represent a statistical district but rather ports of the Tabusintac watershed. A significant increase in landings can be seen beginning in the year 2000, which reflects the digging for clams in contaminated areas for the depuration fishery. Figure 20 shows where the landings were reported. The majority of soft-shell clams in the Tabusintac region were reported at McEacheron Point. Soft-shell clam licenses issued for the Tabusintac region from 1994 to 2006 are presented in Table 6.

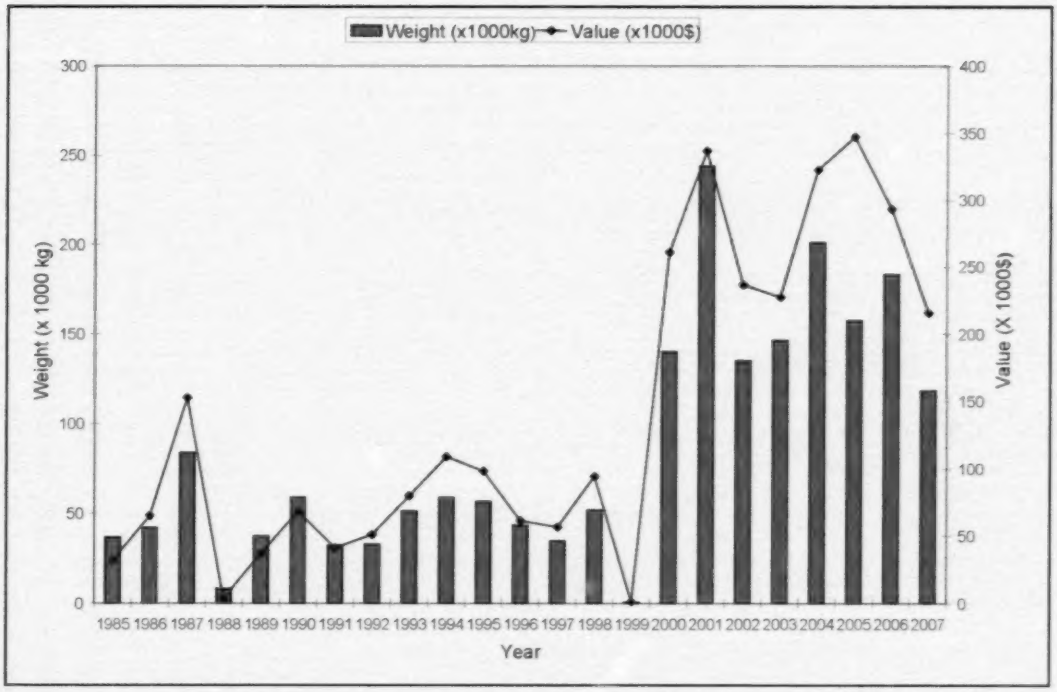

Figure 19. Soft-shell clam landings and value for the Tabusintac region from 1985 to 2007.

(Modified from Fisheries and Oceans Canada, 2006)

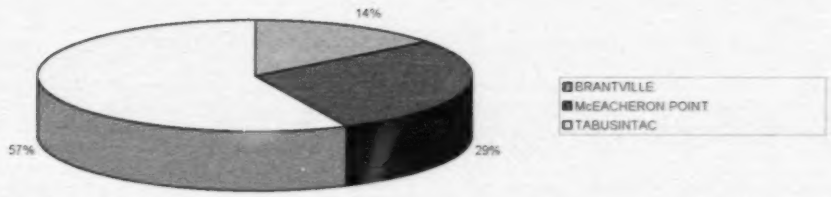

Figure 20. Soft-shell clam percent landings contribution by Port in the Tabusintac region.

(Modified from Fisheries and Oceans Canada, 2006)

Table 6. Soft-shell clam licenses issued for the Tabusintac region by port from 1994 to 2006.

Fishers													
Port	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Brantville	25	24	17	16	16	16	17	20	19	17	19	17	17
Tabusintac	25	51	33	28	27	29	29	29	26	24	24	25	25
McEacheron Point	35	28	18	18	17	16	15	14	13	11	10	11	12
Total	85	103	68	62	60	61	61	63	58	52	53	53	54

(Source: Pers. Com. Michel Bourque – DFO)

5.3. LOCAL KNOWLEDGE

Fishers were interviewed in the Tabusintac region in the fall of 2006. Fishers interviewed from the Tabusintac region have been harvesting soft-shell clams for ~15 to 25 years. Their fishing season usually extends anywhere from May to October. It was estimated that it takes 2 hours to harvest ~15 pecks of soft-shell clams (1 peck = ~14 pounds). More than half of the harvest is rejected on the banks because the clams are too small.

The general consensus for the Tabusintac region is that there are many clams in the area. Surface air supply diving is used to harvest soft-shell clams in the Tabusintac region. Individuals harvesting in contaminated regions use air tubes that allow them to harvest soft-shell clams at all depths of the Tabusintac River except in the channel. It was estimated that 20-25 pecks per day are collected by diving for the catch.

Individuals travel by boat (often in groups ~ 3 per boat) to reach their harvesting regions. In general, the area does not have a lot of access roads and therefore accessibility to the region is somewhat limited. Also, it is difficult to move around on the shore by foot because of the muddy substrate. Figure 21 displays the location of soft-shell clam beds according to the knowledge of local fishers.

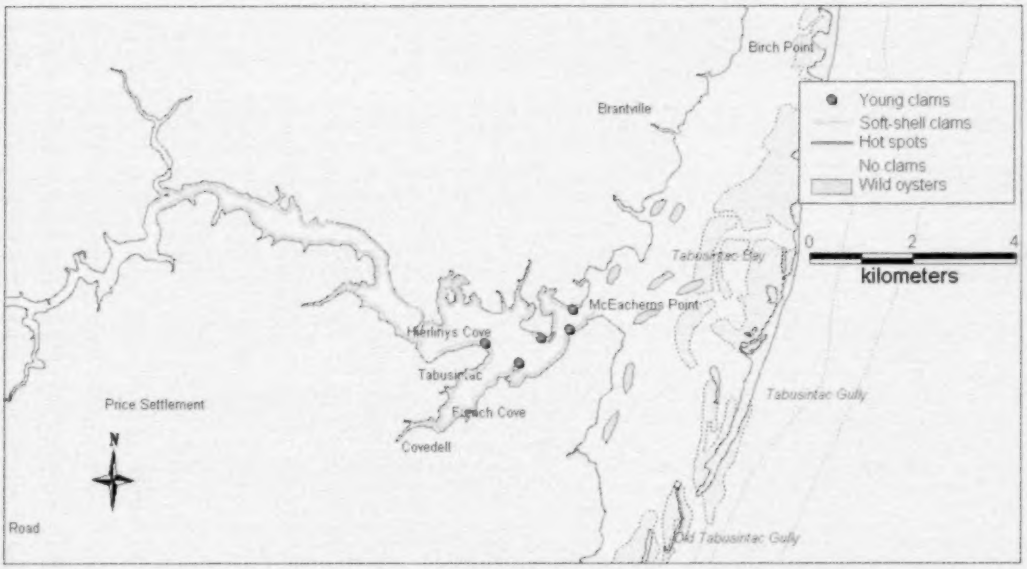

Figure 21. Map of the Tabusintac watershed showing the location of soft-shell clams according to the local knowledge of fishers, fishery officers and NGO's.

6.0. HERON ISLAND

6.1. DESCRIPTION OF AREA & HISTORY

Heron Island is approximately 7 km long (~1.5 km in width) and is located in the upper portion of the Bay of Chaleur. The island is currently non-inhabited however historically small numbers of individuals once lived on the island.

Historically, Heron Island was one of the major commercially exploited soft-shell clam populations in New Brunswick (SenPaq Consultants, 1999). In 1988 the first soft-shell clam survey was conducted on Heron Island. An area of 230 ha was surveyed on the south west side of Heron Island and an estimate of 101,8 T of commercial size soft-shell clams was reported for the area (Biorex Atlantic Inc., 1989). It was concluded that the soft-shell clams surveyed presented high densities, rapid growth and stable recruitment in recent years with no sign of overexploitation.

A second survey conducted in 1995 indicated a decrease in soft-shell clam stocks compared to the 1988 survey. The mean density of commercial size ($\geq$ 50 mm) soft-shell clams decreased from 8.9 ± 33.6 clams/m^2 in 1988 to 1.13 ± 63.0 clams/m^2 in 1995 (Table 7) (SenPaq, 1996). Furthermore, the total population (1000) estimate for

commercial size soft-shell clams decreased from 25,068 in 1988 to 2,262 in 1995 (Table 7) (SenPaq, 1996). As a result of these findings, in 1996 a moratorium was placed on commercial and recreational harvesting of soft-shell clams on Heron Island to allow the stock to replenish from the intensive harvesting that occurred between 1988 and 1995.

In 1997, the Department of Natural Resource & Energy and Eel River Bar First Nation signed a 5 year co-management agreement for Heron Island. During this agreement, money was invested in a number of projects including clean-up, inventory, trail infrastructure, signage, research and fencing (Pers. Com. Tim Dedan). This agreement between the Department of Natural Resource and Eel River Bar First Nation expired in 2000 and was never renewed (Pers. Com. Tim Dedam).

In 1999 a third soft-shell clam survey was conducted and it was found that stocks had increased from 1995, however, did not replenish to the original 1988 survey levels. The mean density of commercial size (≥ 50 mm) soft-shell clams increased from 1.13 ± 63 clams/m^2 in 1995 to 4.11 ± 40 clams/m^2 in 1999 (Table 7) (SenPaq, 1999). The total population (1000) estimate of commercial size soft-shell clams increased from 2,262 in 1995 to 11,578 in 1999 (Table 7) (SenPaq, 1999). Soft-shell clam harvesting on Heron Island reopened in 2003 with a commercial daily fishing quota of 500 clams per day and a recreational daily fishing quota of 100 clams per day.

Table 7. Mean density of legal size clams/m^2 (± 95% confidence intervals) and total population (x1000) of legal size clams on Heron Island in 1988, 1995 and 1999.

Year	Legal size clams/m^2 with 95% confidence interval	Legal size total population (1000)
1988	8.9 ± 33.6	25,068
1995	1.13 ± 63.0	2,262
1999	4.11 ± 40	11,578

Totals are for zones 2, 3 & 4 of Heron Island. Refer to Appendix 3 for identified zones on Heron Island.
(Modified from Senpaq Consultants, 1999)

6.2. LANDING VALUES & LICENSES

Soft-shell clam landings and values for Heron Island from 1987 to 2007 are shown in Figure 21. Note that these are the landings reported for Heron Island only. Soft-shell clams harvested from Heron Island could have been reported at neighboring communities such as New Mills, Charlo, Dalhousie, Jacquet River, Nash Creek and Atholville. Reflected in the graph is the moratorium that was placed on the commercial and recreational harvesting of soft-shell clams on the island from 1996 to 2003. Licenses issued for Statistic District 63 by port from 1994 to 2006 are found in Table 8.

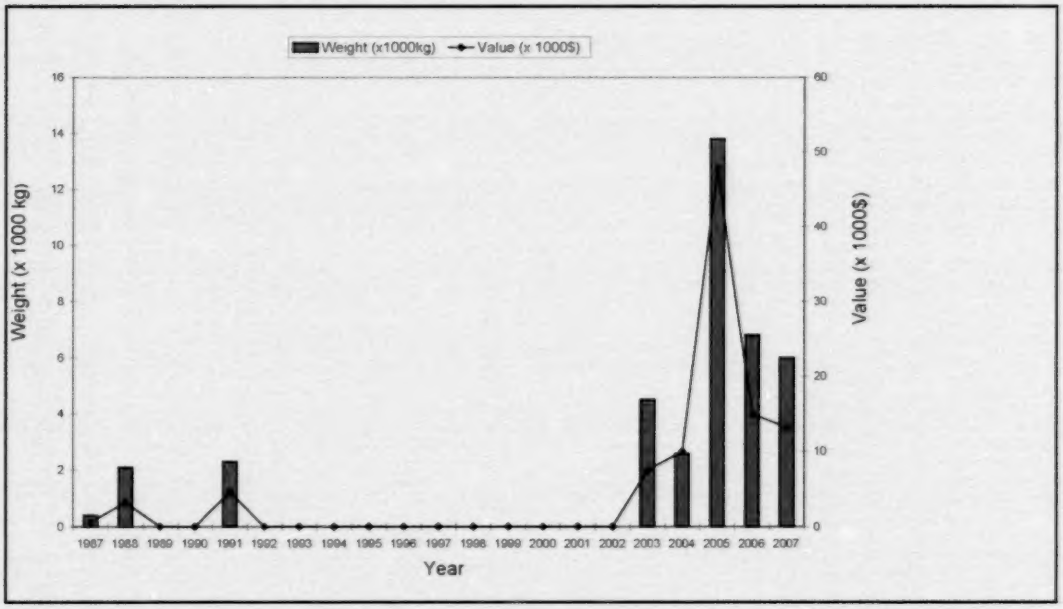

Figure 22. Soft-shell clam landings and Value for Heron Island from 1987 to 2007. *(Modified from Fisheries and Oceans Canada, 2006)*

Table 8. Licenses issued for Statistic District 63 by port from 1994 to 2006.

Fishers													
Port	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Charlo	2	1	1	1	1	1	1	1	1	1	1	1	1
Dalhousie	0	1	46	0	0	0	0	0	0	0	0	0	0
Jacquet River	6	6	4	4	4	4	4	4	4	4	3	3	3
Nash Creek	1	0	0	0	0	0	0	0	0	0	0	0	0
New Mills	14	13	12	7	7	7	7	6	4	5	5	5	5
Atholville	1	0	0	0	0	0	0	0	0	0	0	0	0
Total	24	21	63	12	12	12	12	11	9	10	9	9	9

(Source: Pers. Com. Michel Bourque, DFO)

6.3. LOCAL KNOWLEDGE

Soft-shell clams can be found around the entire Island, however, most soft-shell clam fishing is done in the most sheltered portion of the island on the southern shore (see Figure 23). Individuals usually travel in groups to the island. Upon arrival to the island, a smaller boat is used to get to shore. New Mills is the closest location to leave from to reach the island. Figure 23 displays the location of soft-shell clams according to local fishers.

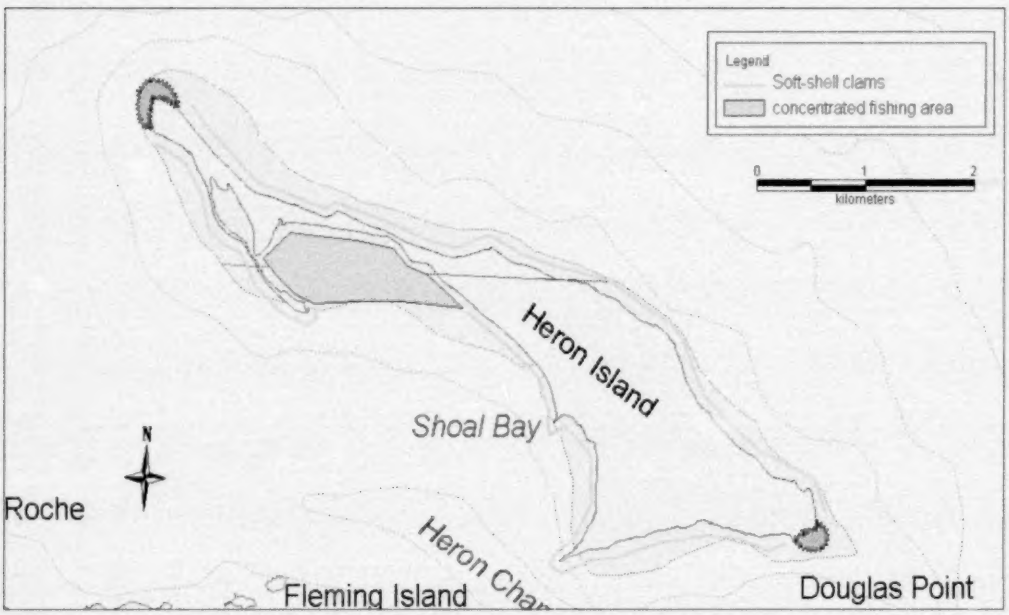

Figure 23. Map of Heron Island showing the location of soft-shell clams according to local fishers.

7.0. CONCLUSION

When it comes down to the state of our soft-shell clams, it is the individuals in the field that are the most knowledgeable about this issue. A fisher may say that it is not worth his/her time to dig in an area, which is insightful information to consider. The gathering and documentation of this local knowledge is important so that this information is not lost over time. Mapping and sampling soft-shell clam beds similarly to this project can give a snap shot of what is presently out there without doing an intensive soft-shell clam population survey. In order to map and sample soft-shell clam beds, multiple partners and co-operation among groups would be needed to cover large scale areas. Baseline information, such as soft-shell clam size distribution, abundance and growth rates, can be used to make management decisions, to evaluate conservation efforts and to describe future productivity of the areas.

8.0. ACKNOWLEDGMENTS

We would like to thank Philippe St-Onge, Jean-François Mallet, Remi Sonier and Angeline LeBlanc, all from Fisheries and Oceans Canada (DFO), for their help in the field and in the laboratory. A special thanks to Florence Albert for all of her help. We would also like to thank Patrice Godin from Environment Canada, Brad Firth (DFO) for his help with mapping applications and Michel Bourque (DFO) for information he provided concerning statistics. Many thanks to the fishers, the Richibucto River Association, the Kouchibouguac Commercial Clam Fishermen Association, the Richibucto River Clam Fishers Association and Tim Dedan who were generous with their information. Funding for this research project was provided by Fisheries Science Collaborative Program (FSCP).

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APPENDIX 1. SEDIMENT CLASSIFICATION

SUBSTRATE CLASSIFICATION	
Mud	Particles with diameter < 0.0625 mm
Sand	Particles with diameter ≥ 0.0625 mm and < 2.0 mm
Gravel	Particles with diameter ≥ 2.0 mm and < 64.0 mm
Cobble	Particles with diameter ≥ 64.0 mm and < 256.0 mm
Boulder	Particles with diameter ≥ 256.0 mm
Bedrock	Solid rock often underlying above substrate types

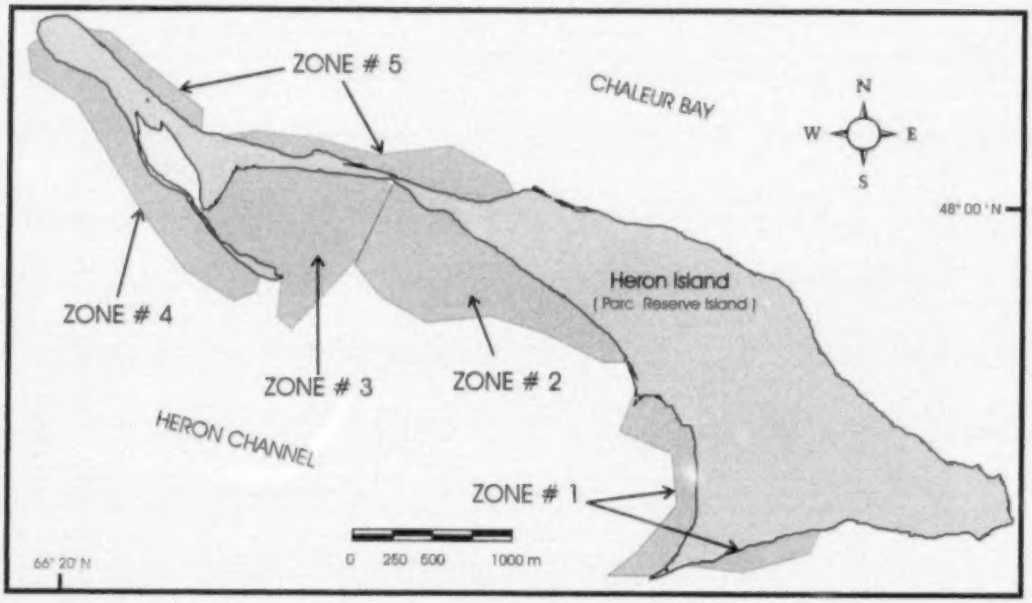
(Source: Wentworth, 1922)

APPENDIX 2. ORGANIC ENRICHMENT STAGES IN CORRESPONDENCE WITH Eh_{NHE} AND TOTAL SULFIDE VALUES

Organic enrichment stage	Eh_{NHE}, mV	Total Sulfide, µM
A Normal	>+ 100	<300
B+ Oxic	0 - 100	300-1300
B- Hypoxic	-100-0	1300-6000
C Anoxic	< -100	>6000

(Source: Wildish et al. 2004)

APPENDIX 3. ZONE CLASSIFICATION ON HERON ISLAND



Map showing identified sectors in the surveyed area along Heron Island
(Source : SenPaq Consultants, 1999)